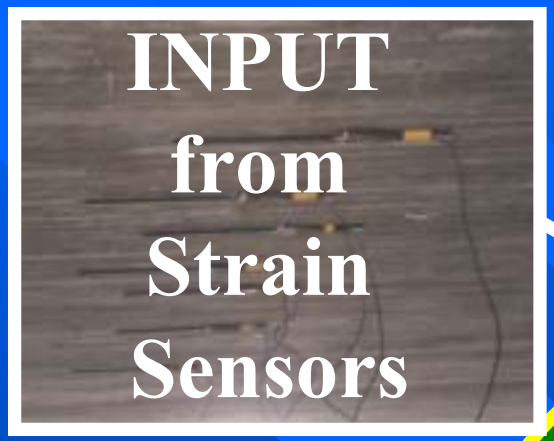
The Influence of Dynamics on Bridge Weigh-In-Motion Accuracy

Arturo Gonzalez & Eugene O'Brien

University College Dublin

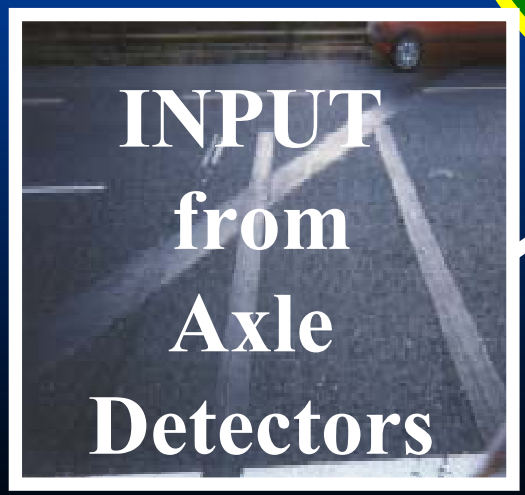
How does a Bridge WIM Algorithm work?



Bridge Strains

Vehicle Speed & Axle Spacings

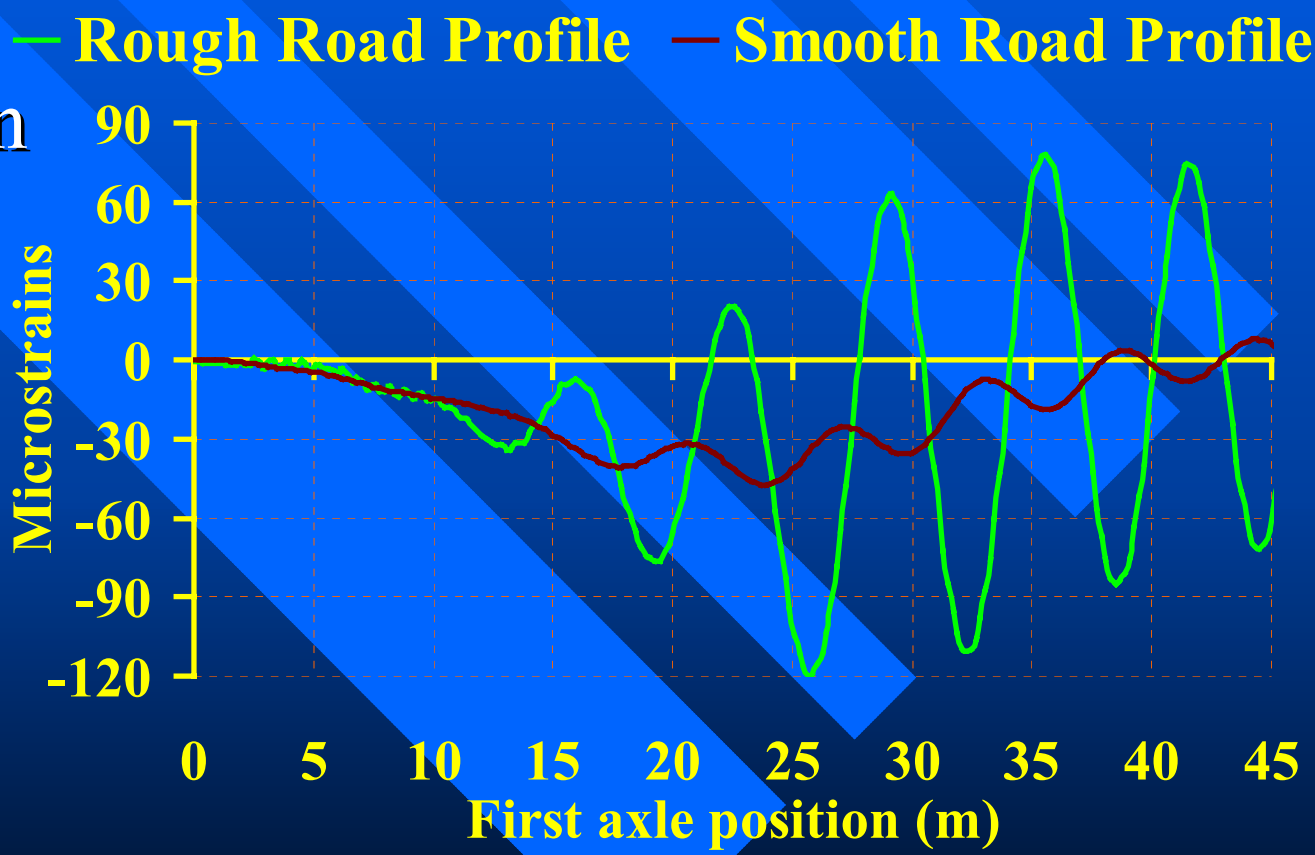
OUTPUT: Vehicle Axle Weights



Mathematical Model of the Bridge Response

Difficulties to Implement B-WIM

- Bridge **Dimensions**
- **Road** Condition

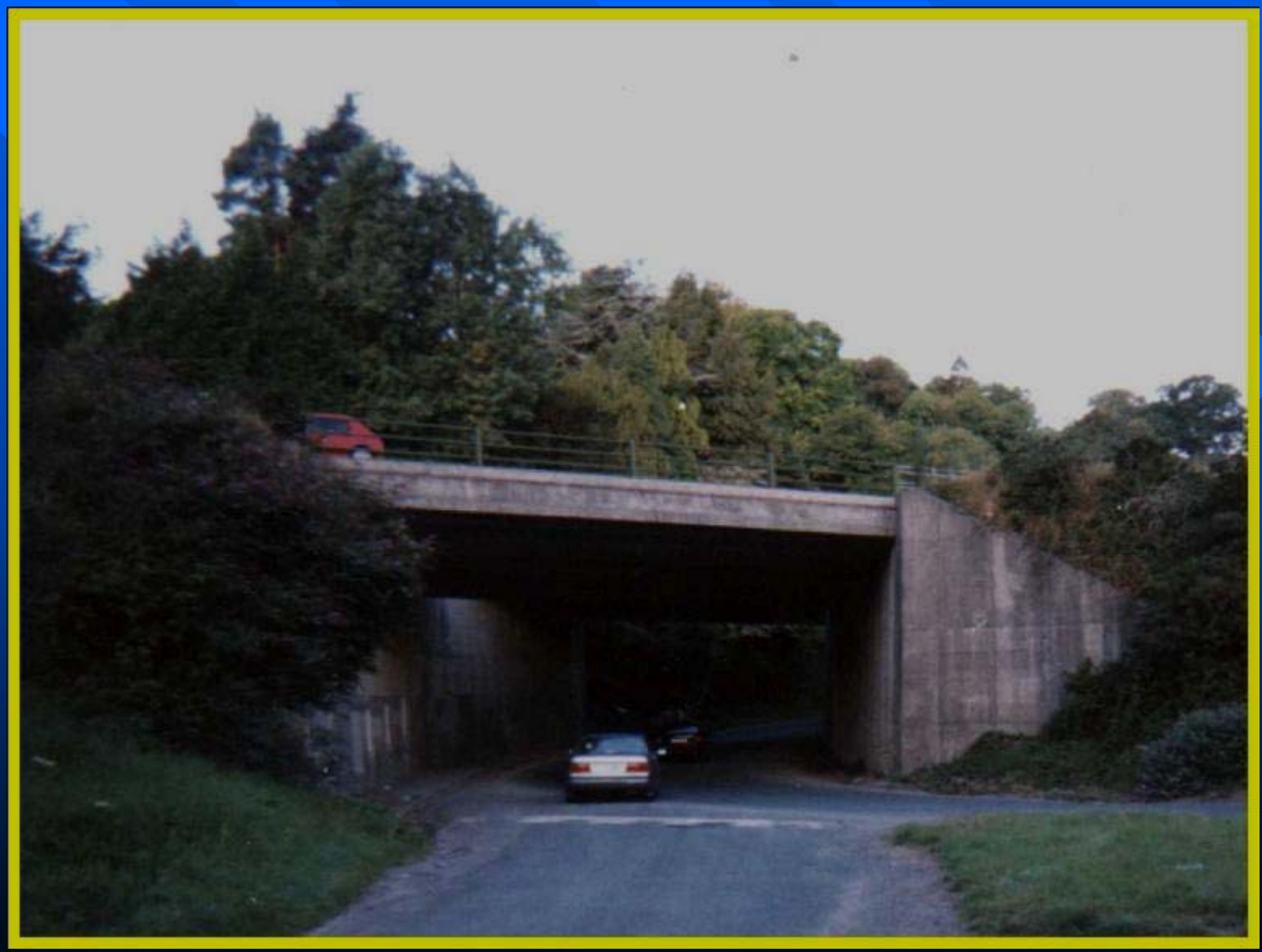


- **Uncertainty** on Bridge Response

Methods to improve Accuracy

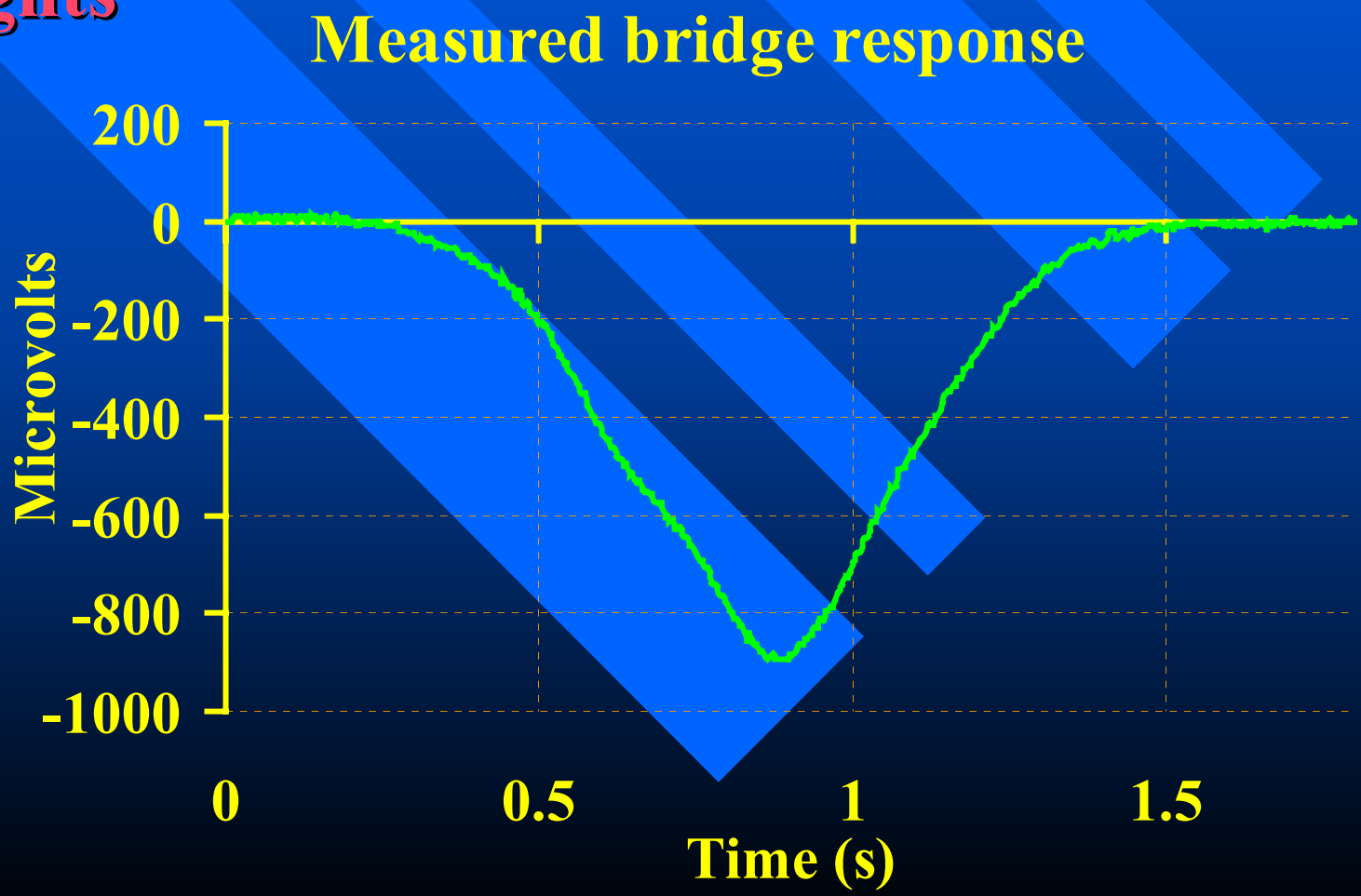
- An **Experimental Calibration**
- A Bridge WIM algorithm based on **Dynamic Equations**
- A Bridge WIM algorithm based on **Multiple Longitudinal Sensor Locations** along the bridge
- Depending on the bridge type, use of measurements **others than Longitudinal Strain at Midspan**

Experimental Calibration Procedure



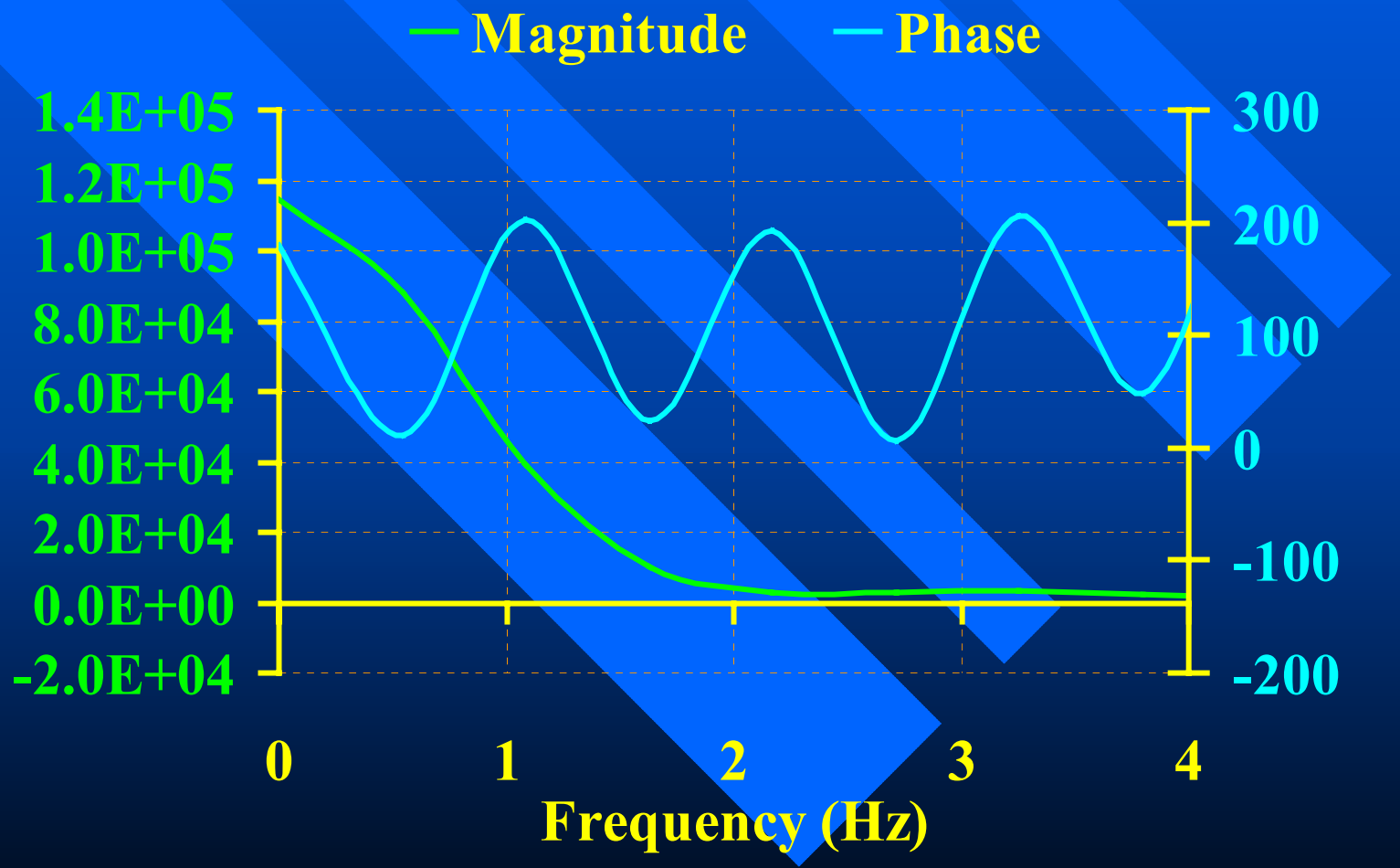
Experimental Calibration Procedure

- **STEP 1: Measure response due to vehicle of known Speed, Axle Spacings and Static Weights**



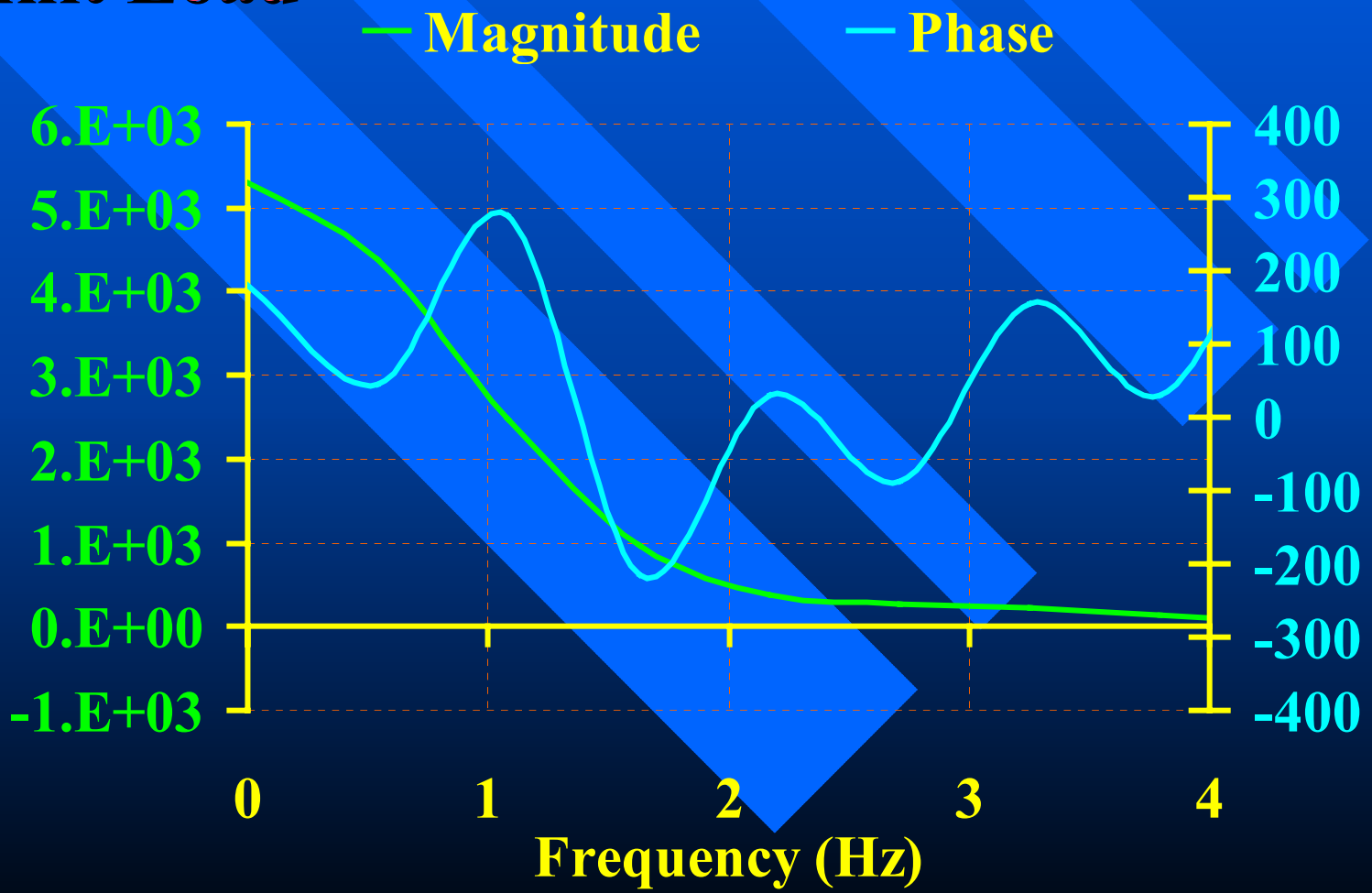
Experimental Calibration Procedure

- **STEP 2: Calculate the total Spectrum**



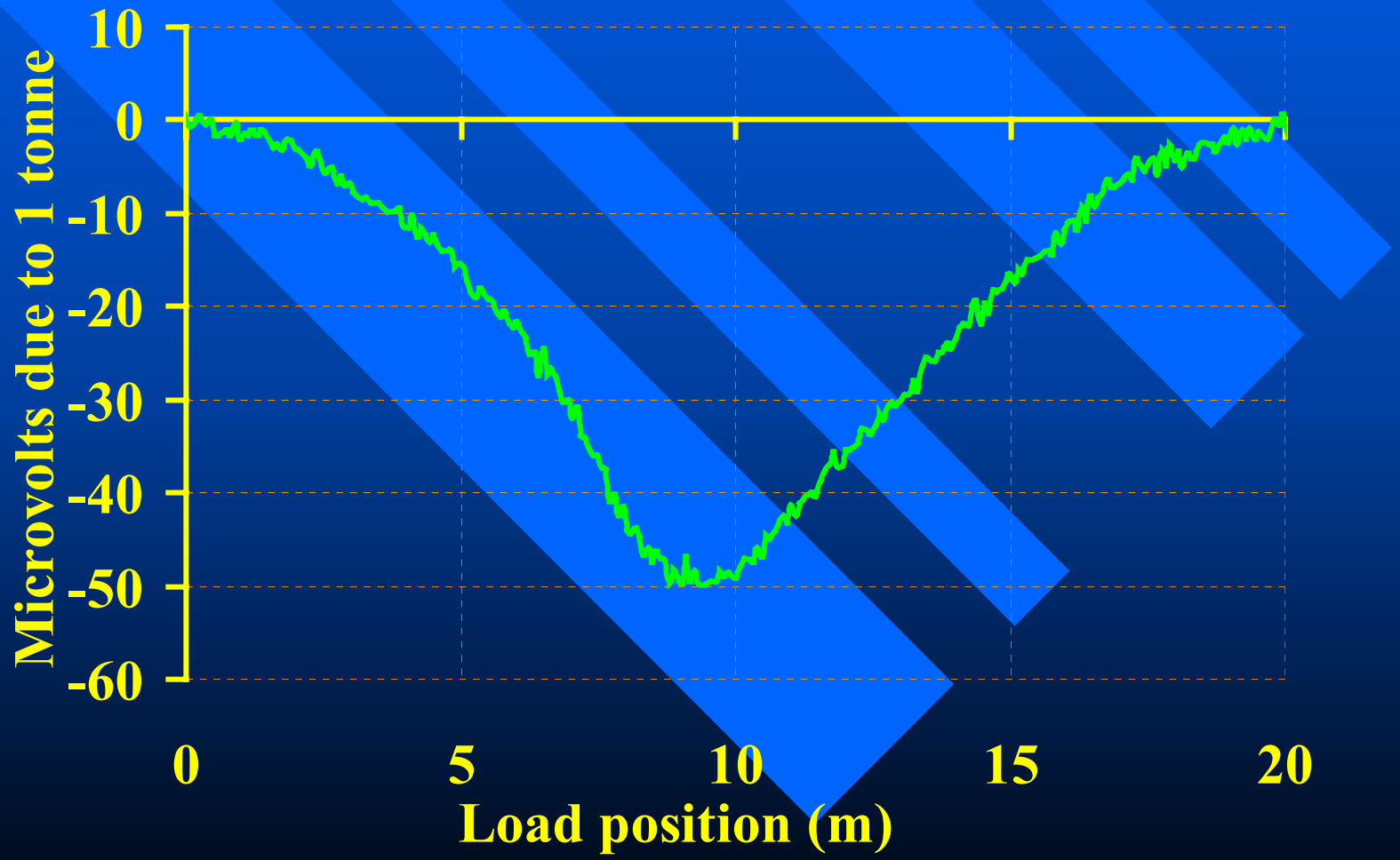
Experimental Calibration Procedure

- **STEP 3: Calculation of the Spectrum due to a unit Load**



Experimental Calibration Procedure

- **STEP 4: Calculate the Influence Line**



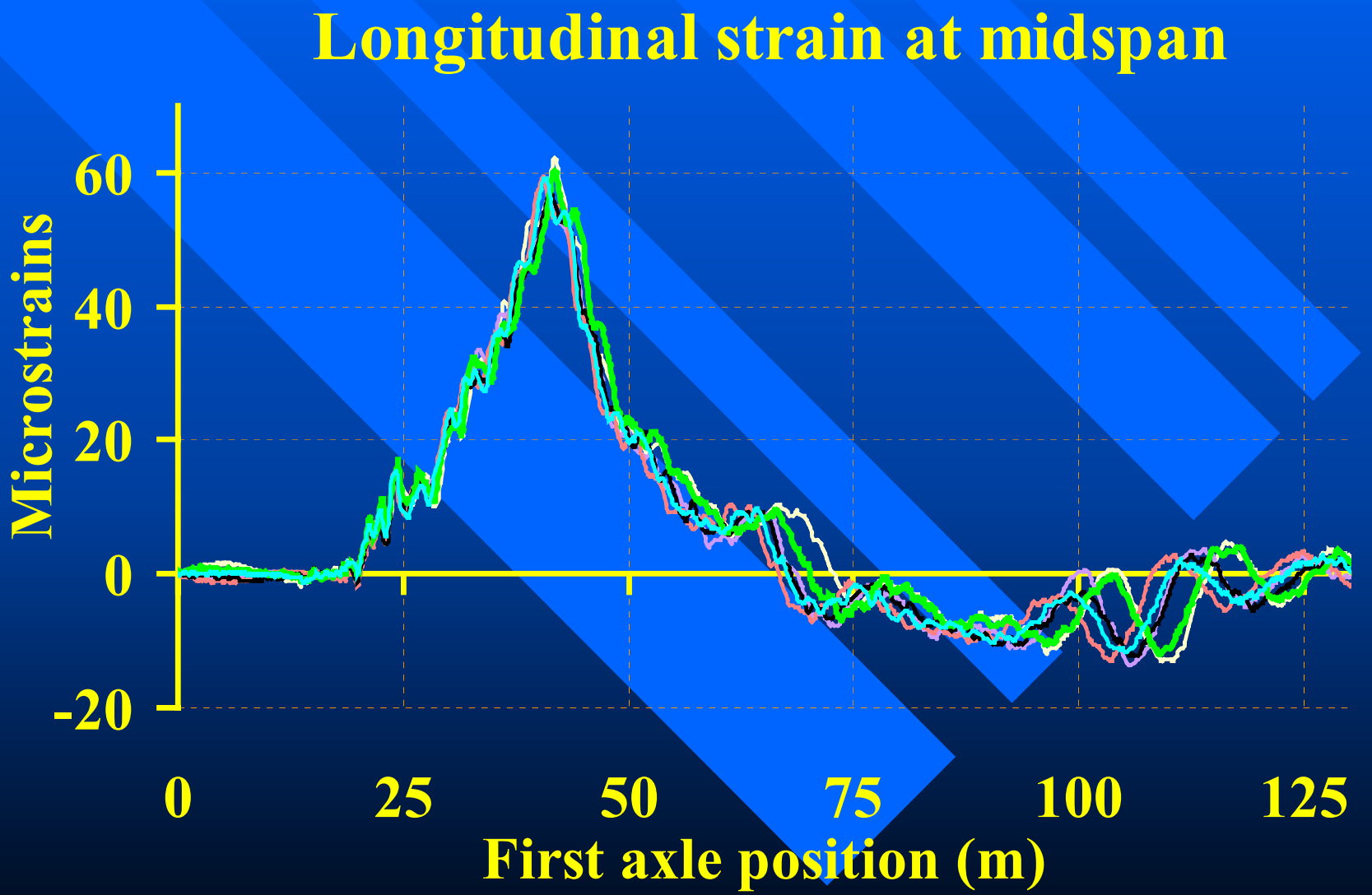
Experimental Calibration Procedure

	Test Conditions	Single Axle	Axle Group	GVW
Bridge 15 m long 30 degrees skew	Extended Repeatability Conditions	C(15)	A(5)	A(5)
	Full Repeatability Conditions	A(5)	A(5)	A(5)

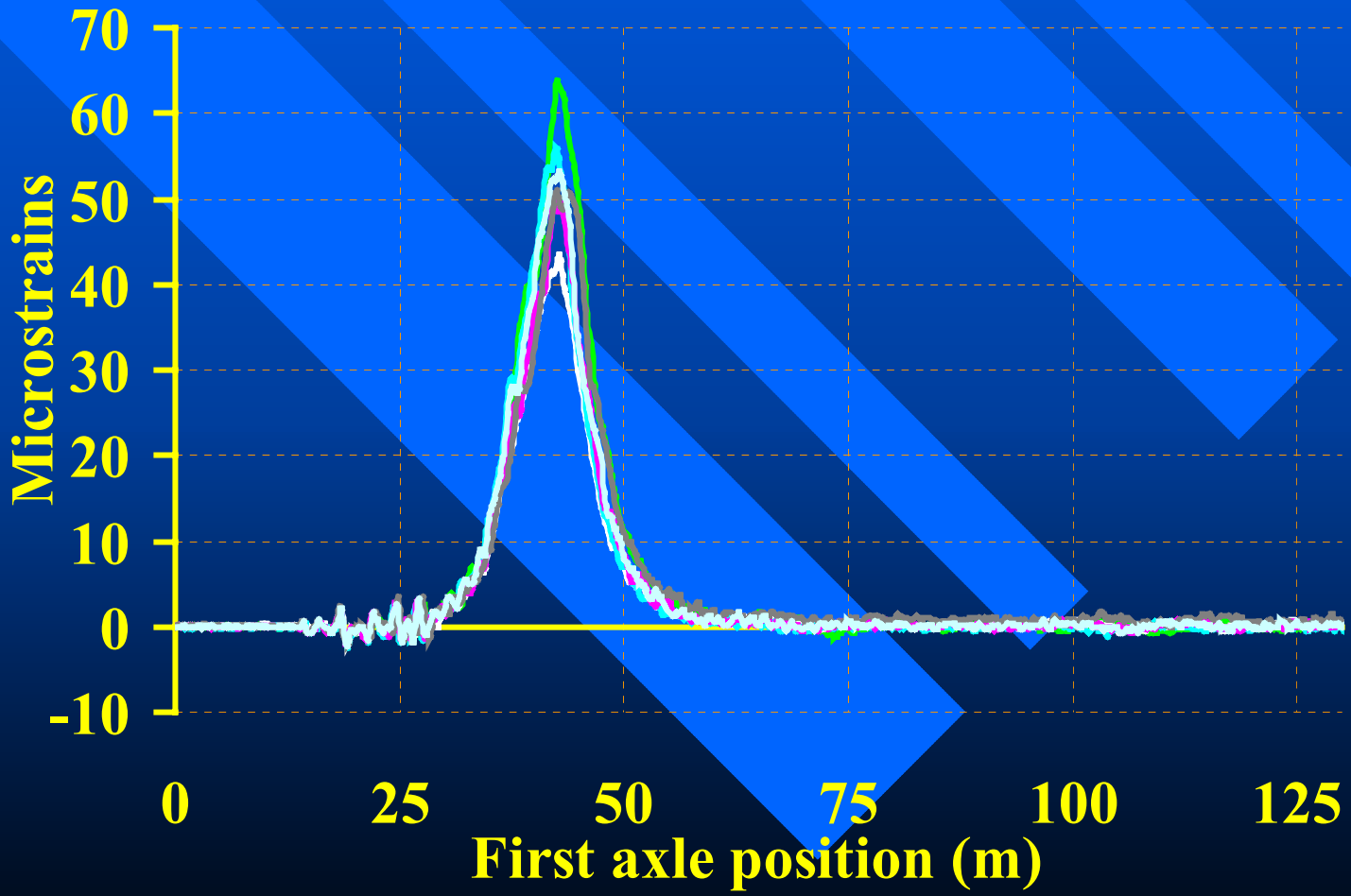
A Dynamic B-WIM Algorithm

- **Total Strain** response compared to response from a theoretical **Bridge Dynamic Model**

A Dynamic B-WIM Algorithm

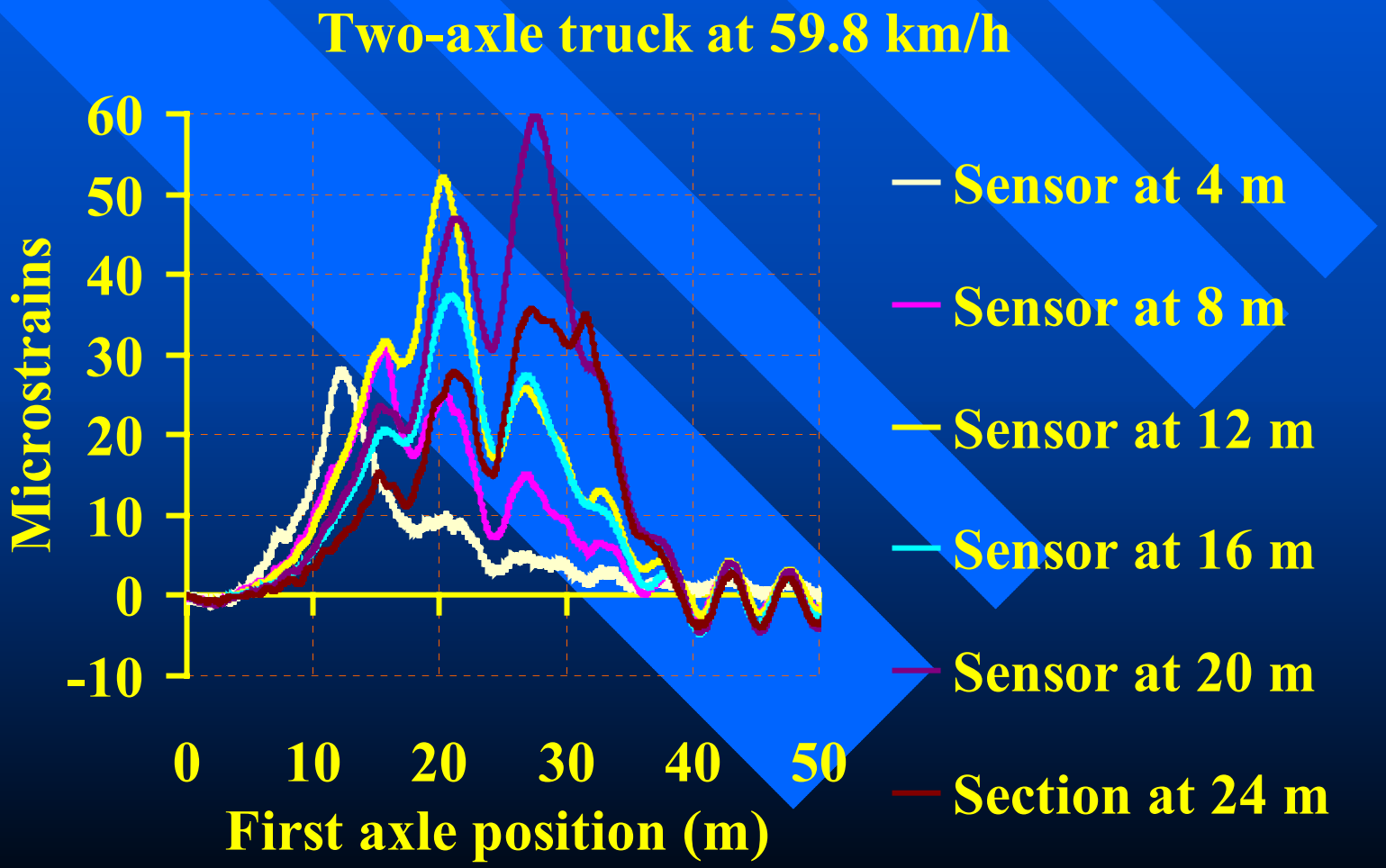


Transverse Strain at Midspan of Box Girder Bridge

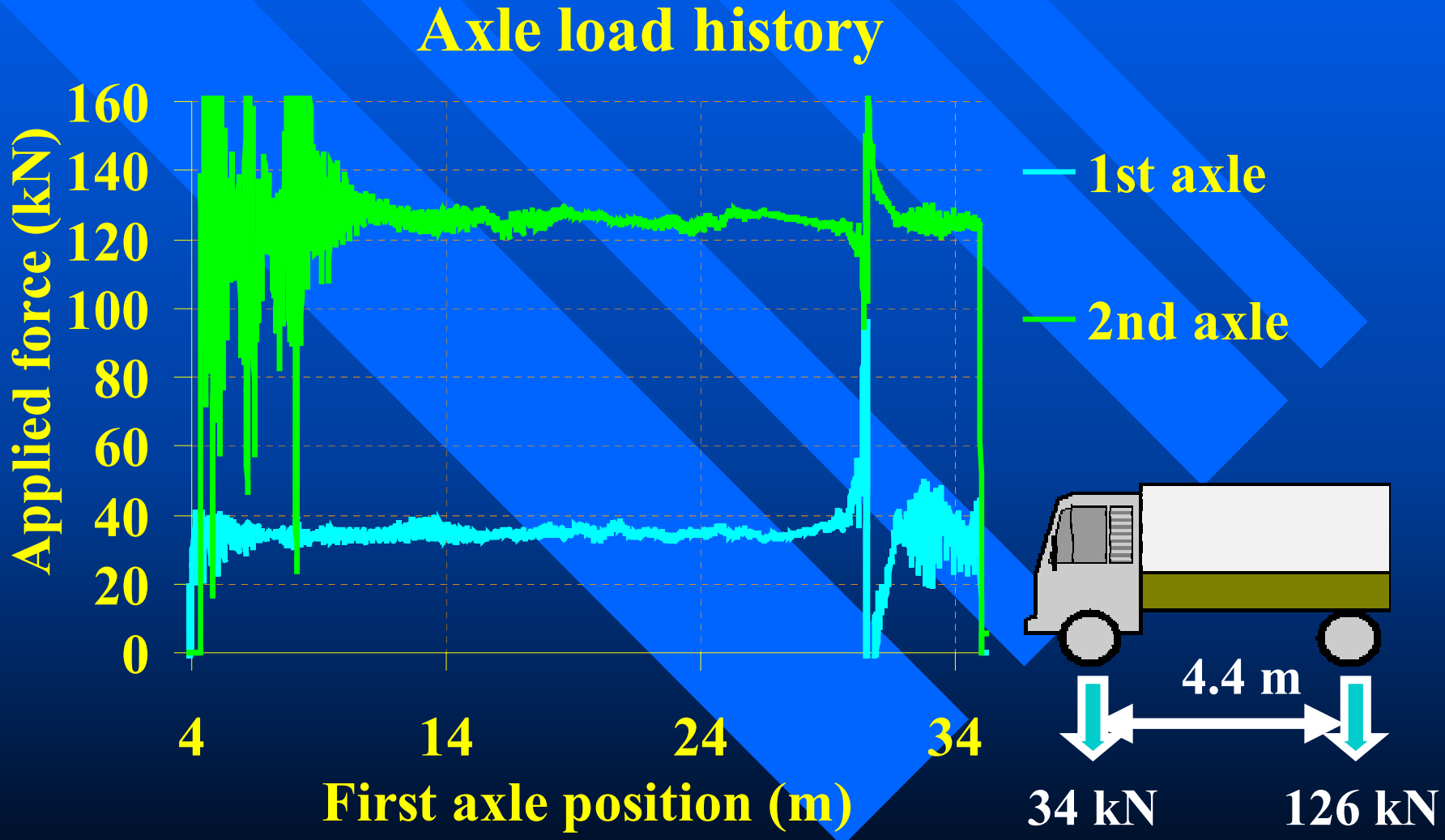


Multiple-Sensor Bridge WIM

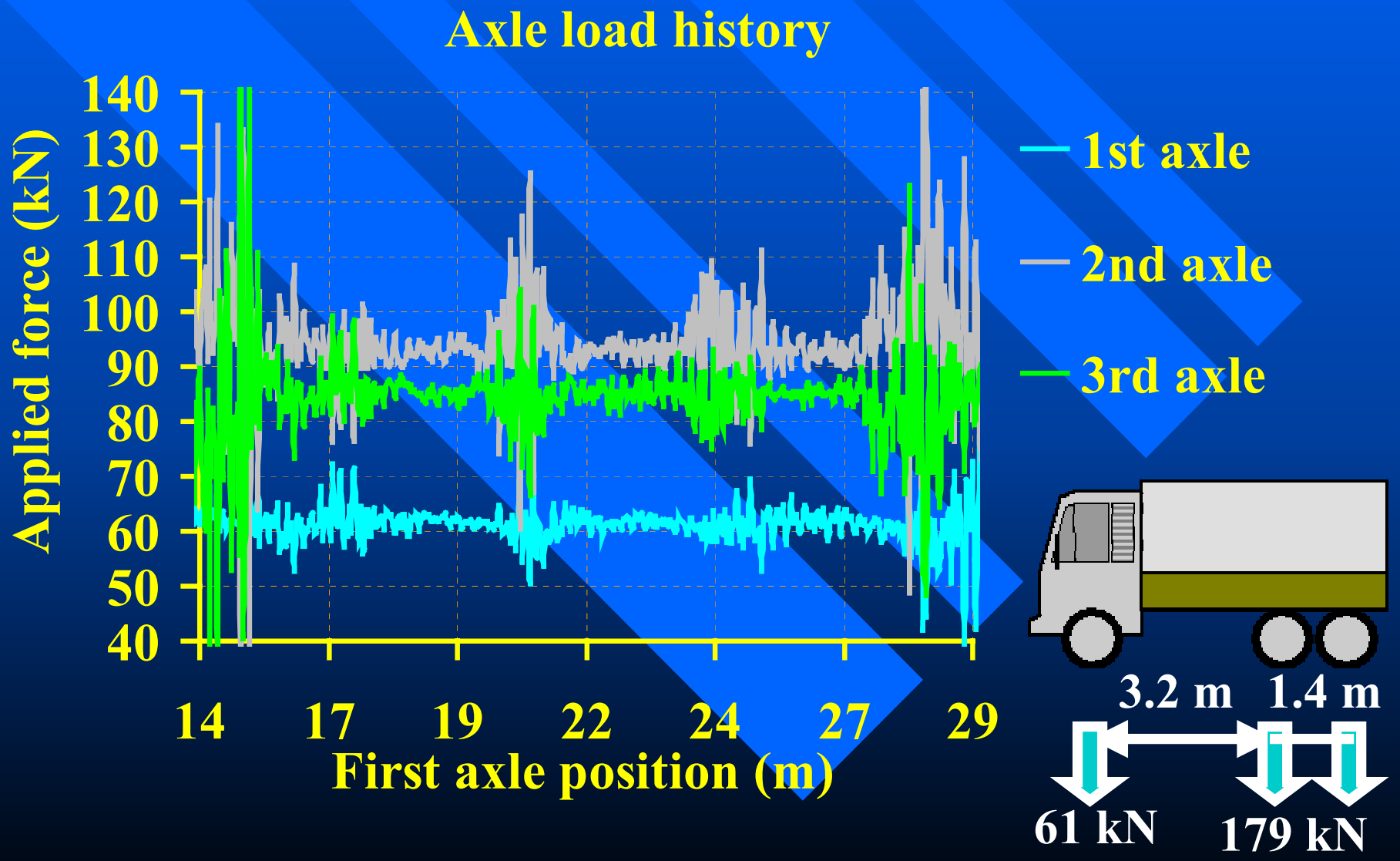
- Principle: System of equations (**One Equation for each Strain Sensor**) at each instant



Multiple-Sensor Bridge WIM

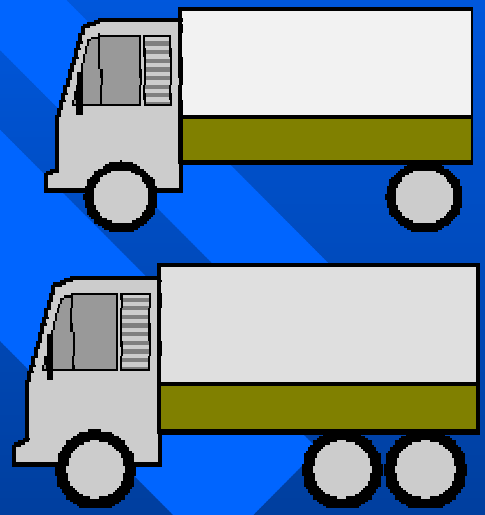


Multiple-Sensor Bridge WIM



Finite Element Simulations

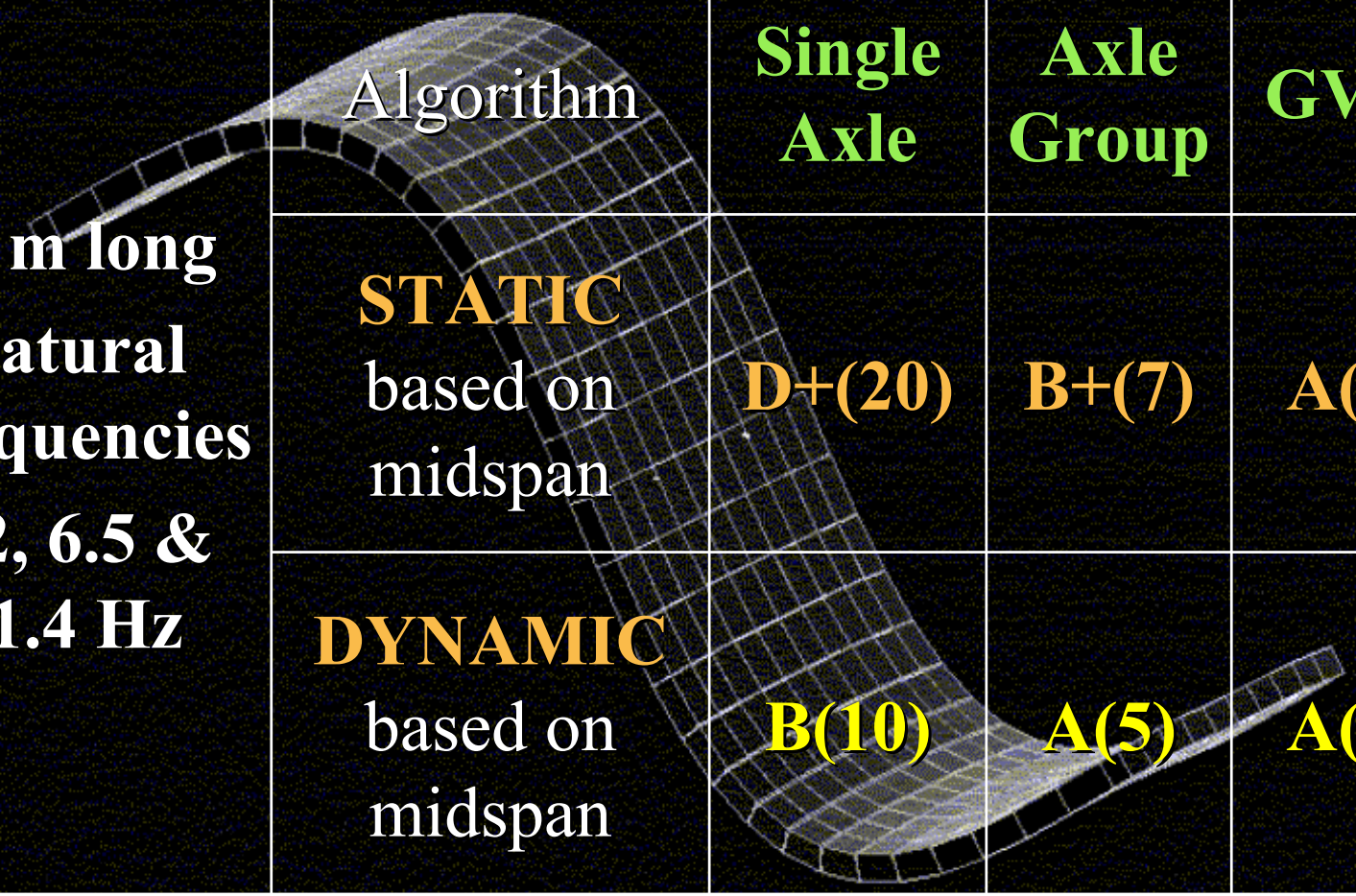
- **Two trucks** (rigid frame 2 and 3-axles) running at **3** different **speeds** (55, 70 & 85 km/h) and **3** different **loading conditions**.



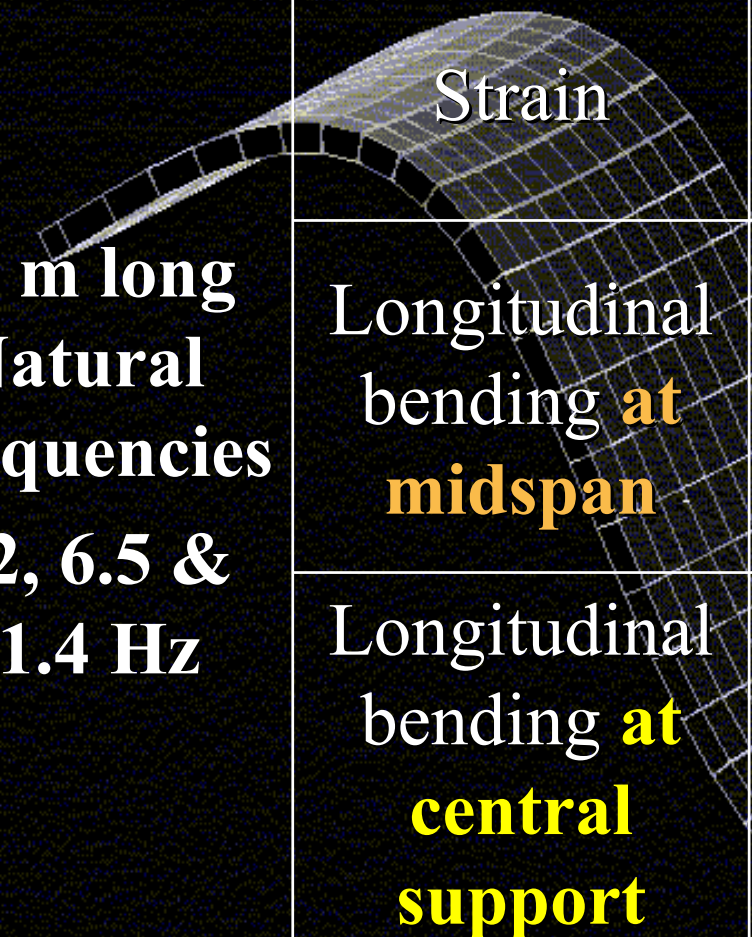
- Bridge Models:
  - A **two-Span isotropic** Slab 36 m long
  - A **Beam&Slab** Bridge 20 m long

Accuracy Results for FE Simulations on a Two-Span Isotropic Slab

	Algorithm	Single Axle	Axle Group	GVW
36 m long Natural Frequencies 4.2, 6.5 & 11.4 Hz	**STATIC** based on midspan	**D+(20)**	**B+(7)**	**A(5)**
	DYNAMIC based on midspan	**B(10)**	**A(5)**	**A(5)**

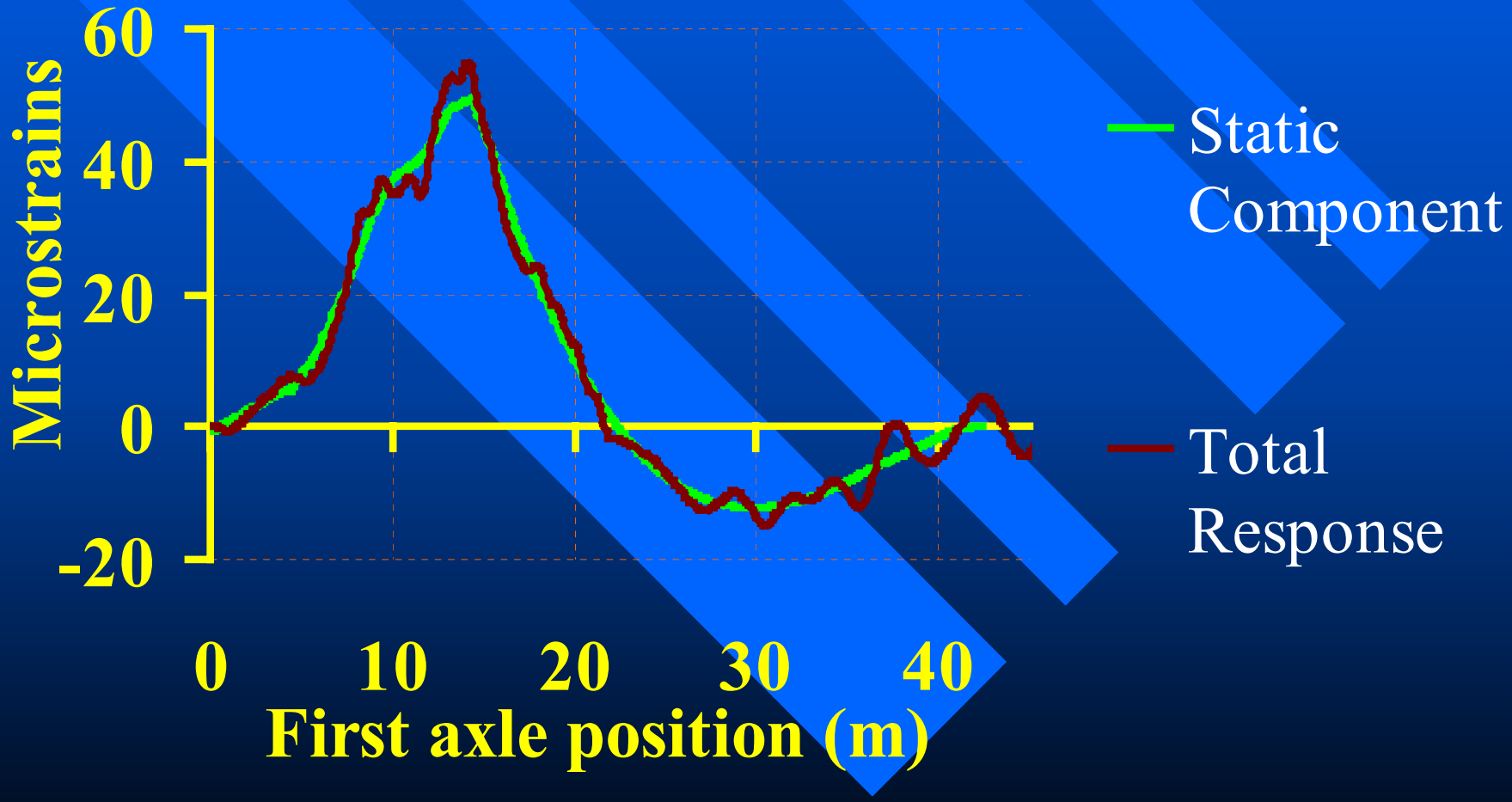


Accuracy Results for FE Simulations on a Two-Span Isotropic Bridge

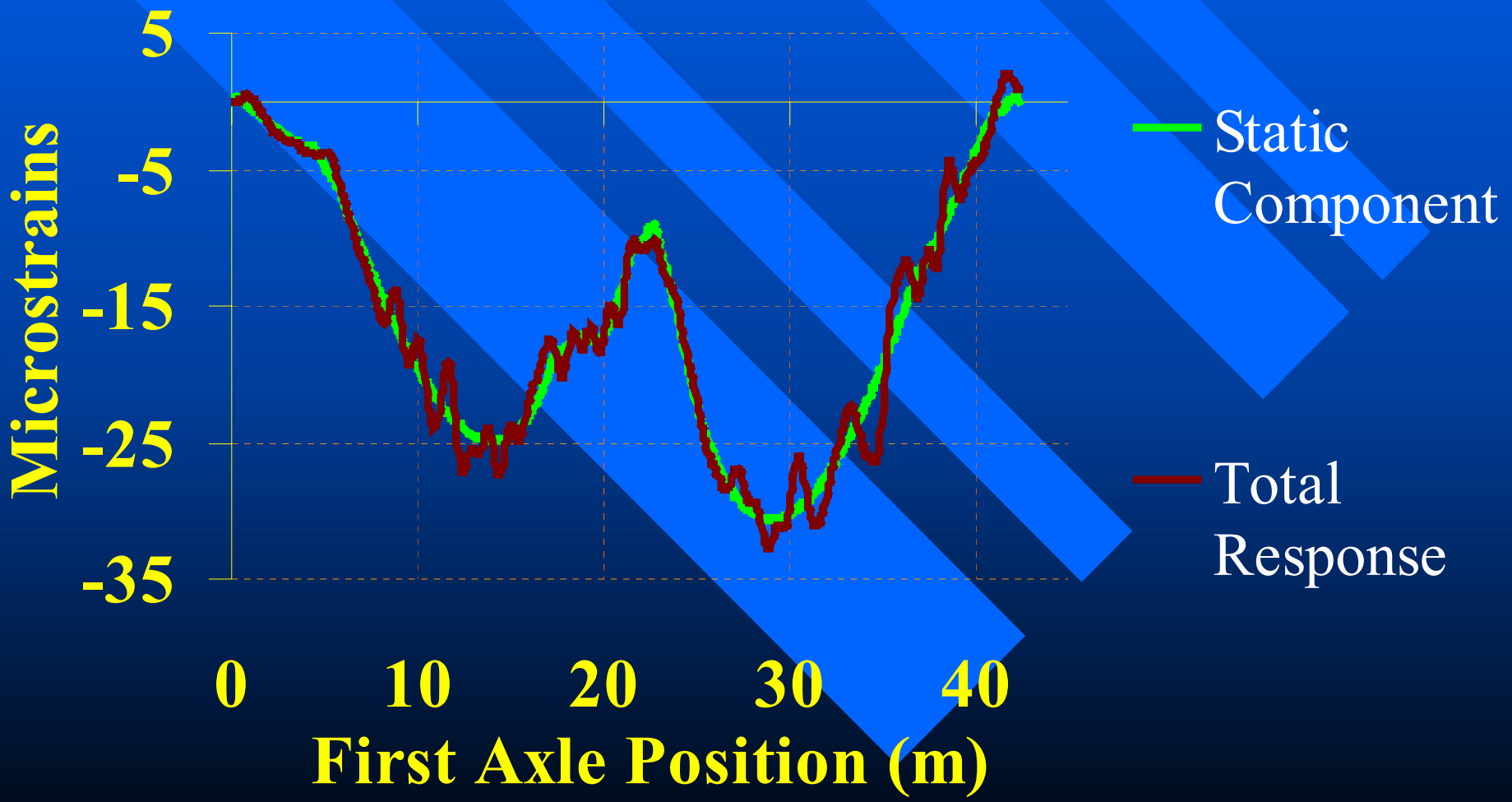


	Strain	Single Axle	Axle Group	GVW
36 m long Natural Frequencies 4.2, 6.5 & 11.4 Hz	Longitudinal bending **at midspan**	**D+(20)**	**B+(7)**	**A(5)**
	Longitudinal bending **at central support**	**A(5)**	**A(5)**	**A(5)**

Strain at Midspan of 2-Span Bridge due to a 3-axle Truck at 70 km/h

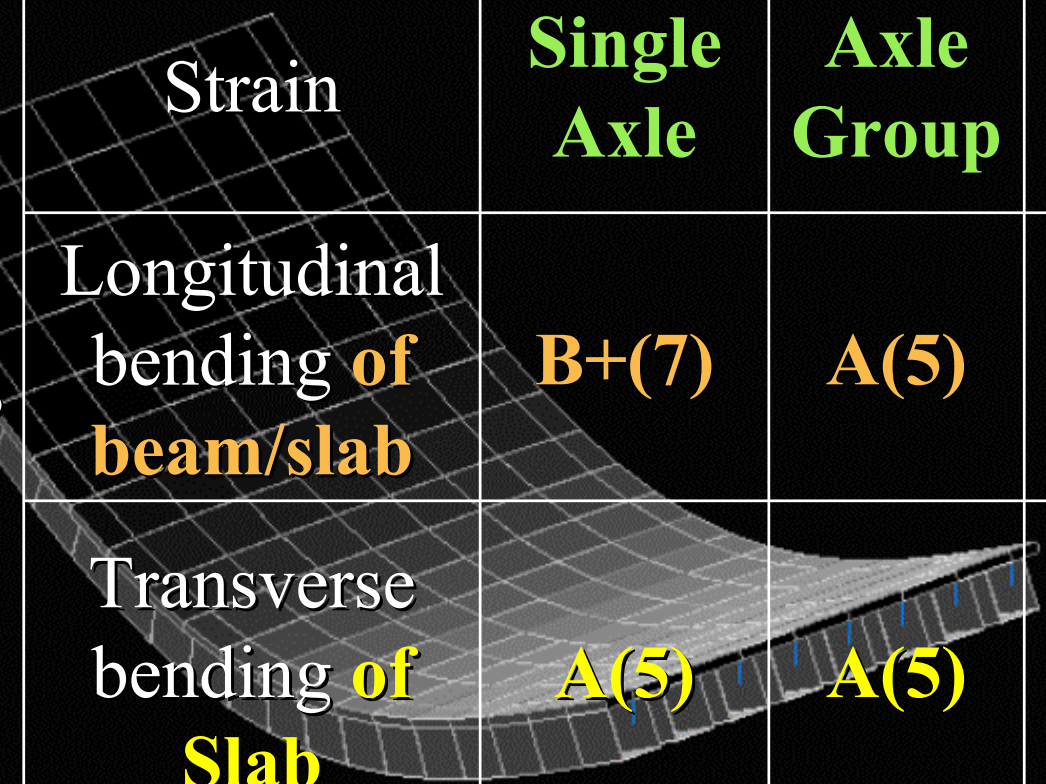


Strain at Central Support of 2-Span Bridge due to 3-axle Truck at 70 km/h

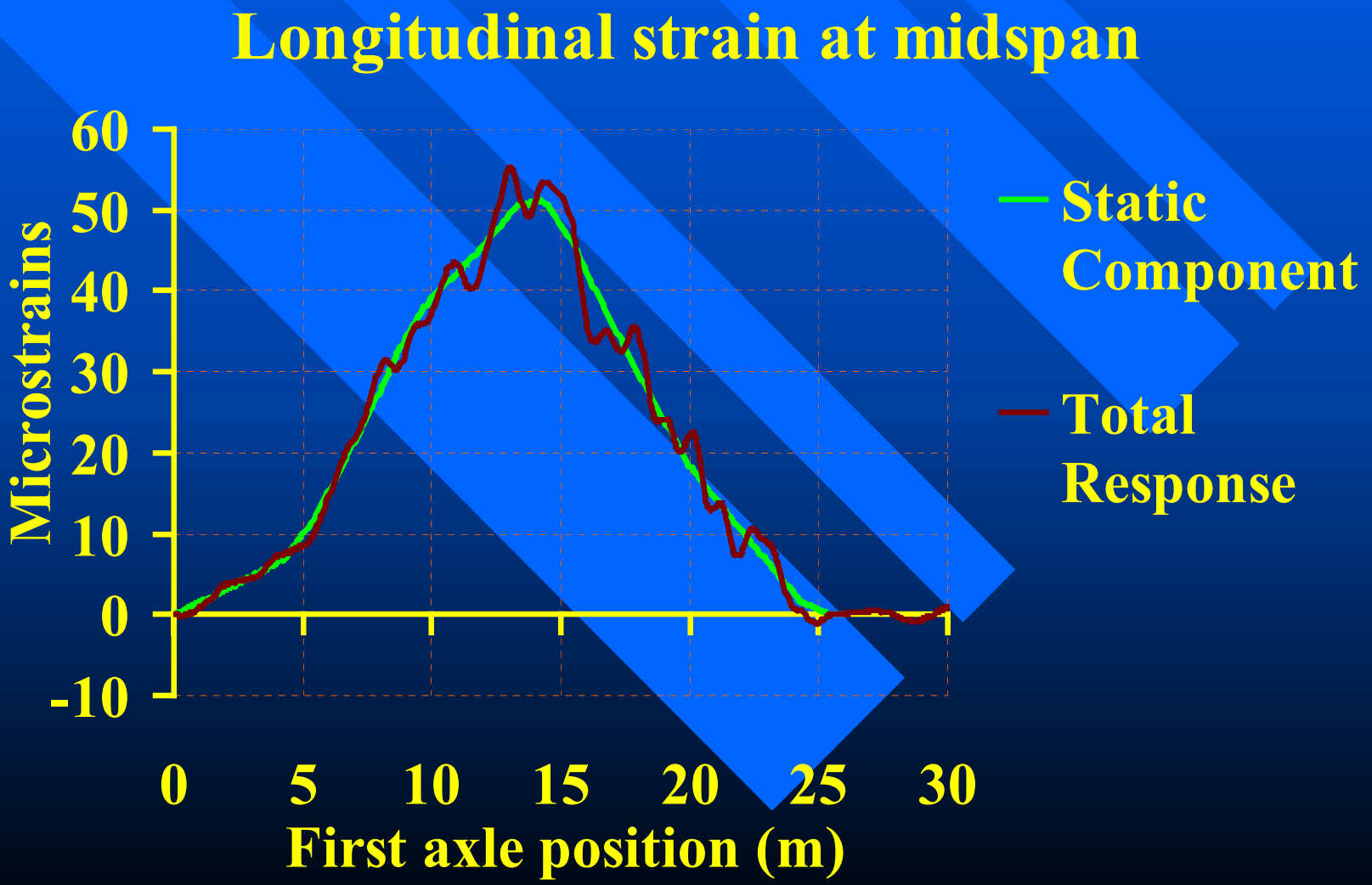


Accuracy Results for FE Simulations on a Beam & Slab Bridge

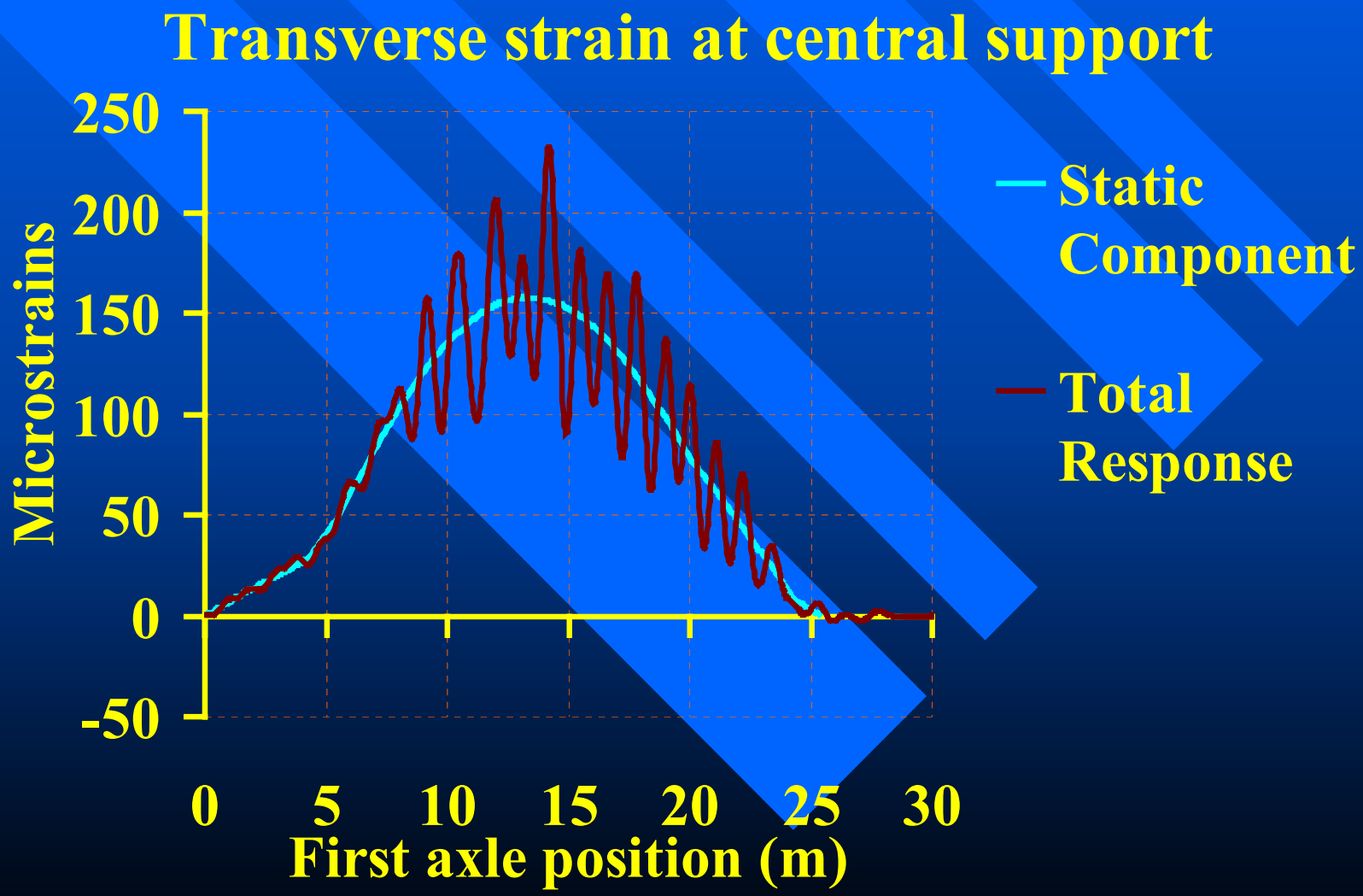
20 m long Natural Frequencies 6.1 & 7.4 Hz	Strain	Single Axle	Axle Group	GVW
	Longitudinal bending of beam/slab	B+(7)	A(5)	A(5)
	Transverse bending of Slab	A(5)	A(5)	A(5)



Response of a Two-Span Bridge due to 3-axle Truck crossing at 70 km/h



Response of Two-span Bridge due to 3-axle Truck crossing at 70 km/h



Conclusions

- Results from using:
  - an **Experimental Calibration** Procedure,
  - a **Multiple-sensor B-WIM** algorithm,
  - the measurement of **Longitudinal Strain at the central support** of a continuous bridge,
  - and the measurement of **Transverse Strains**

  appear to improve accuracy **for some Bridge Decks** significantly and further testing is required.